DOCUMENT RESUME

ED 391 300 EC 304 549

AUTHOR Oller, John W., Jr.; Rascon, Dana
TITLE Explaining Autism: Its Discursive and Neuroanatomical Characteristics.
PUB DATE [95]
NOTE 44p.; Paper presented at the Annual Meeting of the American Association for Applied Linguistics (Long Beach, CA, March 25-28, 1995).
PUB TYPE Information Analyses (070) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Autism; *Cognitive Processes; *Etiology; Logic; *Neurology; Neuropsychology; *Semiotics; Severity (of Disability); Symptoms (Individual Disorders); *Theories
IDENTIFIERS Aspergers Syndrome; Infantile Autism; *Peirce (Charles S); Williams Syndrome

ABSTRACT

This paper reviews the existing empirical research on autism in the context of the semiotic theories of Charles S. Peirce. His ideas of the generalized logic of relations are seen as explaining the unusual associations (or lack thereof) in autism. Concepts of "indices" or signs singling out distinct objects, and "adinity" or the number of distinct logical objects that must be kept track of, are first explained. These concepts are then applied to three kinds of disorders: (1) severe autism, which is also called Kanner-type autism (recognizable in early infancy); (2) Asperger syndrome, a milder and sometimes undetected variety of autism; and (3) Williams syndrome (not generally associated with autism at all). Analysis shows certain commonalities and also marked differences in each of the three disorder types. Peirce's semiotic theory (concerning linguistic, gestural, and sensory systems) is coupled with a review of relevant medical research and both observational and experimental approaches to the discourse analysis of affected individuals. Whereas Williams syndrome is thought to be due to a metabolic dysfunction which disrupts coordination of sensory-motor information with abstract reasoning, infantile autism and Asperger syndrome are seen as being due to damage to the limbic system affecting the ability to link deictic markers of various sorts with their logical objects in representational systems. (Contains 51 references.) (Author/DB)

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Explaining Autism: Its Discursive and Neuroanatomical Characteristics

John W. Oller, Jr. and Dana Rascón

University of New Mexico

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Abstract

Perhaps the most unyielding mystery among well-known communicative disorders has been the case of autism in its various guises. Based on advances in Peircean semiotics, three kinds of disorders are examined—(1) severe autism, which we will call Kanner-type autism (recognizable in early infancy); (2) Asperger syndrome, a milder and sometimes undetected variety of autism; and (3) Williams syndrome (not generally associated with autism at all). Analysis shows certain commonalities and yet marked differences in each of the three categories examined. Based on semiotic theory (concerning linguistic, gestural, and sensory systems) coupled with a review of relevant medical research and both observational and experimental approaches to the discourse analysis of affected individuals, an explanation of each of the categories of communicative disorders and their severity is offered and correlated with a proposed neurological basis in each instance. The limits of the observed severity in each category are explored with the aid of the theory under consideration. While Williams syndrome is probably owed to a metabolic dysfunction which disrupts coordination of sensory-motor information with abstract reasoning; infantile autism and Asperger syndrome are probably owed to damage to the limbic system affecting ability to link deictic markers of various sorts with their logical objects in representational systems.

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In 1994, neurologist Oliver Sacks wrote in a popular journal that, "No theory, as yet, encompasses the whole range of phenomena to be seen in autism.... The ultimate understanding of autism may demand both technical advances and conceptual ones beyond anything we can now dream of" (1994, p. 107). While contending that the condition has always been around and that it must have affected individuals "in every period and culture" (p. 106), Sacks notes that it was not until the fourth decade of the 20th century that it came to be known by the term **autism**, and even now, just what that label means remains a significant mystery. In the 1940s both Leo Kanner (Kanner, 1948) and Hans Asperger (cf. Gillberg, 1985) independently proposed the term "autism" noting that the disorder in question was specially characterized by some degree of mental exile from the external world—hence the term "autism" (or "self-ism") suggesting the essential isolatedness of the affected individual. But what is the cause of this unusual and debilitating disorder? Is it to be sought in genetics? The social environment? Metabolic processes? Nutritional deficiency? Chemical damage to tissues? Disease? Or, perhaps, some combination of these?

A Bit of History

From the beginning, Kanner and Asperger differed in their descriptions and explanations for autism. For instance, Kanner stressed the "obsessive insistence on sameness" shown by rituals and routines, departure from which would often result in panicky behaviors and sometimes self-inflicted injuries. From Kanner's descriptions, we get a picture of an extreme mental stasis of a usually pre-verbal individual, whose abnormality is often accompanied by difficulties with balance and movement. Vocal gestures where they are observed are apt to be explosive, non-syllabic and unspeech-like, also revealing difficulties with motor control. In fact, extreme retardation often accompanies Kanner-type, or "infantile" autism and it is not uncommon to see neurological symptoms characteristic of cerebral palsy and Parkinson's

disease.

In Asperger descriptions, however, we find an abnormal, but usually *not* preverbal individual. The descriptions from Asperger emphasize lack of eye-contact, strangeness of gestures, unnatural speech, disregard of environmental factors, failure to take social constraints into consideration, and difficulties in managing affective aspects of communication. However, especially with Asperger-type autistics, unusual mathematical and musical abilities are sometimes observed. Typically, even such gifted autistic individuals appear to be peculiarly dependent on a linear connection between elements of experience, performance, or thought. For instance, Temple Grandin (a gifted, Asperger-type, autistic with a Ph.D.) describes her ability to recall a sequence of events in a way that resembles the viewing of a videotape. She points out that it is necessary to start at the beginning of the memory and review it all the way through as if living through the events depicted there all over again in just the sequence in which they originally occurred. Perhaps this is why she says,

> I do not fit in with the social life of my town or university.... My interests are factual and my recreational reading consists mostly of science and livestock publications. I have little interest in novels with complicated interpersonal relationships, because I am unable to remember the sequence of events (as quoted by Sacks, 1994, p. 113).

As Sacks notes, owing to the emphasis of Kanner on the possibility that autism might be induced by the social environment of a child, it was not until Bernard Rimland's text appeared on *Infantile Autism* in 1964 that it came to be realized quite generally that autism must, at least in many cases, have a genetic basis, or, at least, a basis involving chemical or other damage to genetic material. In fact, it was soon discovered that the children of autistics were more likely also to be autistic and that the disorder was far more common in males than in females. Other disorders also thought to be genetic in origin were observed commonly to be associated with autism. Among these were a diffuse class of maladies ranging from dyslexia and attention deficit hyperactivity disorder (Oller & Damico, in press), bipolar affective disorder (Gillberg, 1985; DeLong & Dwyer, 1988), Tourette's syndrome (Kerbeshian & Burd, 1986), epilepsy

(Simblett & Wilson, 1993, p. 87) and even adult schizoid personality disorder and schizophrenia (Wolff & Chick, 1980; Wolff & Cull, 1986). Today it is known that autism can be caused by disease and possibly by chemical insults to the developing zygote or fetus. The rubella epidemic of the 1960s (Sacks, 1994, p. 108) is believed to have produced autistic babies because their mothers were affected by the disease, and there is suspicion that perhaps even exposure to ethanol (ordinary consumable alcohol) in pre-natal development may in some cases be linked to autism (cf. Shoemaker, Kehoe, & Baker, 1992). It is known that autism or its symptoms may be produced through metabolic or mechanical problems and may accompany a host of neurological problems including tuberous sclerosis (in 5% of the cases of this condition; Gillberg, 1988) and Rett syndrome (Reiss, et al., 1986). It may even develop late in adult life owing to "certain forms of encephalitis" (Sacks, 1994, p. 108). Autism has also been linked recently with fragile-X syndrome (12.3% to 21% of subjects with this disorder are also autistic), neurofibromatosis, phenylketonuria, Cornelia de Lange syndrome, and Williams syndrome (Huebner, 1992, p. 494). Further, there is no doubt that classical infantile autism (which we sometimes refer to as "Kanner-type" autism) tends to be correlated genetically with diagnosed Asperger syndrome. DeLong & Dwyer (1988) found that 68% of 51 persons with high-functioning infantile autism had family members or near relatives (siblings, parents, grandparents, aunts, uncles, or cousins) who had been diagnosed as having Asperger syndrome (also see Huebner, 1992, p. 495).

Recently, Ursula Bellugi and her colleagues at the Salk Institute, together with Terry Jernigan at the San Diego VA Medical Center, have teamed up to study Williams syndrome. This less common disorder resembles autism of the Asperger variety in certain respects though it involves some aspects that are very different from and in some ways almost the opposite of autistic disorders. No doubt the single most distinctive aspect of Williams syndrome (first noted by Williams, et al., 1961) is the inability of the afflicted individual to articulately relate spatio-temporal settings to linguistic descriptions in the normal way. For instance, a certain 15 year-

old girl says:

> You're looking at a professional book writer. My books will be filled with drama, action, and excitement. And everyone will want to read them. I'm going to write books, page after page, stack after stack... I'll start on Monday (as cited in Bellugi et al., 1992, p. 205).

Up till this youngster says she will start on Monday, everything seems to be going swimmingly. But a strange note appears there. The authors write:

> At first glance, this young woman has the makings of a novelist, but, in fact, she has an IQ of 49 and has Williams syndrome. At the age of 15, she fails all Piagetian seriation and conservation tasks (normally attained by the age of 7 years), goes to a special school in classes for the mentally retarded, has reading, writing, and math skills comparable to those of a first grader, demonstrates visuospatial abilities of a 5-year-old, and requires a babysitter for supervision (p. 205).

Or, for a dramatic visual illustration (also from Bellugi et al.), compare the drawing of an elephant at the top of Figure 1 with the verbal description by the 18 year-old with Williams syndrome who drew the picture and the two pictures involving bicycles drawn at the bottom by another person with Williams syndrome on the left and a matched Downs patient on the right.

Insert Figure 1 about here

In fact, though the various manifestations of the disorders under consideration—infantile autism, Asperger syndrome, and Williams syndrome—are often distinct, to describe them as unrelated is to run into difficulty with the pervasive association of not just these but many other mental disorders as well (cf. Martineau et al., 1992). Especially disorders that involve genetic or chemical components tend to affect whole complexes of interrelated biochemical, neurological, and other organic systems within the brain and throughout the body (Hanschu, 1995). Nevertheless, our theoretical perspective on the discursive and neuroanatomical bases of the several disorders considered here, is offered merely as a source of hypotheses to be examined more closely in subsequent research. What we put forward at this stage is a

theoretical perspective that is richer in certain respects than any other that we know of up to this date, and which we hope may provide the basis for beginning to unravel the mystery of autism and its possible relationship to other disorders such as Williams syndrome. Though we think these disorders are susceptible to the sort of theoretical analysis we are recommending here, we see the theory itself as applicable more broadly to mental and communicative disorders (also, see Oller & Damico, in press). Further, such disorders in turn seem to be especially useful testing grounds for the theory. Our assumption is that if the applicability to autism can be demonstrated, the interest of other researchers may be piqued to examine additional ramifications relative to the broader class of communicative and mental disorders. It is, therefore, the theory itself, as much as the disorders in focus, that we wish to explore.

From the very beginning of the original research into autism by Kanner and Asperger, it was noted that autistic subjects lacked the ability, motivation, or both, to connect themselves with the external world in normal ways. Yet agreement is still lacking on just what autism is even as we approach the twenty-first century. Among the current disputes over the symptoms and what they mean is whether autism is mainly an emotional or primarily a cognitive disorder. The debate on these alternatives is summed up nicely by Ruth Huebner in 1992 citing various authorities on both sides. Hobson (1986), and Fein et al. (1986), for example, argue that autism is basically an emotional disorder which blocks subsequent cognitive development, but Baron-Cohen (1991) and Leslie & Frith (1990) contend just about the opposite—that autism involves such a severe cognitive deficit that affective consequences are bound to follow. What is agreed to by all is that autistic persons have difficulties on *both* affective and cognitive tasks.

There is also evidence that autistics differ greatly from normals and other contrast groups in forming cross-modal associations (Martineau, Roux, Garreau, Barthélémy, & Lelord, 1992). Associations across modalities such as auditory-to-visual (a heard stimulus associated with a visual one or the reverse), visual-to-vocal (a visual stimulus linked to a vocal response or the reverse), as contrasted with visual-to-visual and auditory-to-vocal, were found to produce

greater differences for autistic subjects than normals or other contrasted groups. In fact, the 17 autistic subjects examined by Martineau et al. (1992) could be divided into three subgroups where radically divergent patterns were observed. The first subgroup (n = 5) performed well below the level of normal subjects on cross-modal tasks. The second (n = 8) performed about as well as normals, and a third subgroup (n = 4) performed higher than normals. Autistic children in the third subgroup, seemed to fixate more attention than normal on a given stimulus connection to the exclusion of other possibilities and thus to increase the associative bond of the cross-modal association. We will have more to say about this phenomenon later.

In fact, the oddity of associations in autism, or in some cases the almost complete lack thereof, is commonly mentioned in the research literature as perhaps its single most definitive feature. Regardless whether we are looking at subjects with extreme autism, Asperger-types (some of whom show proclivities of the "savant" kind), or even Williams syndrome individuals, it is ability to form certain kinds of associations that crops up again and again in all the literature. For instance, in extreme infantile autism, associations of all kinds are conspicuous by their absence. In Asperger syndrome, however, two kinds of symptoms are observed pertaining to associations. First, the kinds of association that can be handled are much more limited than in the normal case, and the particular kinds of associations that are possible tend to be emphasized to an extreme degree. For instance, in the case of autistic savants, a musical piece heard only once may be played back from rote, or a difficult problem of computation or counting may be solvable in a mysterious way—an example being the famous twins who could recite prime numbers to four, five, and six digits requiring many difficult computations to be carried out rapidly in their heads. In the case of Williams syndrome, the breakdown involves the integration of sensory-motor representations with verbal and reasoning functions. In particular, ability to integrate verbal signs with sensory-motor signs is disrupted on the one hand, and to a lesser extent semantic associations are also disrupted and may also be carried to extreme esoteric levels.

One of the most insightful experimentally-based descriptions of autism with respect to its peculiar manifestations in the associative aspects of pragmatic language use, comes from Churchill (1978; cf. DeLong, 1991). Churchill used a simplified pragmatic context with three objects (block, ring, stick), three color attributes (red, yellow, blue), and three transitive actions (give, tap, slide). The last three elements, unfortunately, are not quite as similar as the first two sets are. While "tap" and "slide" are transitive acts that may be performed on a single object by the autistic subject, "give" necessarily involves a third grammatical (or logical) position—in addition to the person doing the giving and the object given, there is the recipient or person to whom the something in question is given. Nevertheless, in Churchill's ingenious experimental method, certain definite limits on the capabilities of autistics were revealed.

Churchill observed, among other things, that no amount of practice seemed in the least to move the autistic individual from a certain established level of comprehension and production to any higher level. The author wrote, for instance, concerning a subject named Jonathan, that

> once a set is established for talking about what he is dong *or* what I am doing *or* what he has *or* what I have, Jonathan is well able to give correct answers endlessly, even when dozens of different objects or positions are introduced—so long as those objects or positions stay within *the same response set*. But to talk interchangeably about what he is doing *and* what I am doing *and* what he has *and* what I have leaves him demonstrably incompetent (as cited in DeLong, 1991, p. 64).

Churchill concludes that

> when...multiple stimuli come to have syntactical relationships to each other even the highest functioning autistic child demonstrates incompetence... To use discriminative stimuli in two different dimensions or sets simultaneously appears immediately to exceed the linguistic competence of such children. We have seen no evidence that the underlying rules of grammar...can be taught. And the autistic child, however good his speech, seems locked into a concrete world in which only one dimension can be responded to at a time (as cited by DeLong, 1991, p. 64).

DeLong interprets the Churchill research as demonstrating

> a limited capacity for higher-order association... (a) Each child showed a rigid ceiling in the number of components of language that he could respond to accurately. (b) This ceiling seemed to be nearly absolute;

> it could not be expanded or overcome even by intensive practice or alternative learning techniques even after several months of effort. (c) The children willingly cooperated and responded accurately, repeatedly, and appropriately to those language stimuli (word combinations) that were within their response capacity; that is, the limitations on their performance did not appear to be volitional, motivational, or affectively based. Rather it was cognitive: a limitation in the capacity to process multiple conjoined language elements (DeLong, 1991, p. 64).

More explicitly, DeLong notes that if the child were capable of handling two elements, if a third were presented within a syntactic relation, it would be dealt with "in an error mode—either randomly, or perseveratively, or not at all" (p. 65). Then, Delong goes on to argue that many aspects of autistic behavior and limitations are mirrored in research with patients (or experimental animals) who have suffered damage to the hippocampus. DeLong argues, therefore, that because the hippocampus is known to be crucially involved in building syntactic links between sensory-motor stimuli, memories, and concepts, that it must play a critical role in the neuroanatomy of autism.

Other researchers too have examined the missing "syntactic links" of autistic behavior and have noted the crucial role they play in the storage and retrieval of sensory-motor representations. For instance, Eichenbaum, Cohen, Otto, & Wible (1991) note that

> there is now abundant evidence that the hippocampal system, whose damage produces a profound amnesia, has a selective role to play in memory, contributing to only one type of memory or one of the brain's memory systems. This system apparently supports the conscious recollection and explicit remembering of facts and events. By contrast, systems outside of hippocampal structures support changes in skilled performance, as seen in skill learning, repetition priming, perceptual adaptations, and conditioning.... It is our view that the hippocampal system supports *declarative memory*, characterized by a fundamentally *relational* representation in which memories are highly interconnected, can be activated by all manner of inputs and can be accessed and flexibly expressed in any number of novel contexts. Non-hippocampal systems support *procedural memory* characterized by a *non-relational* form of representation in which memories are functionally independent of one another and inflexibly dedicated to particular processing situations or contexts (pp. 209-210).

The thesis put forward by Eichenbaum et al. is that the person with a damaged or destroyed

hippocampus is a person whose experience in the present tense (the "declarative" mode) is disconnected from the past and future. Present experience cannot be actively construed in a syntactic way by declaring the relations of various elements of experience and then linking these elements with similar facts or events stored in memory because the necessary syntactic links cannot be built. Sensory inputs may appear to be normal from the position of the observer on the outside, but for the person suffering from such a hippocampal disconnection, memories can neither be accessed through associations with present experience. nor can they be modified by experience, nor can they be used in the normal way in order to anticipate what will occur in the future. Therefore, Eichenbaum et al. suggest, the person suffering from such a dislocation has the sort of experience that they describe as "the snapshot without the album". Another metaphor that suggests itself is a brief video loop disconnected from the rest of the tape. The problem, apparently, for such an individual is something like that of a person with normal perceptual sensations but who cannot cognitively connect the phenomenally present moment with anything past or future.

The Need for a More Comprehensive Theory

So far, we have a few pieces of the puzzle, but it is increasingly obvious that we do not have the whole of it. What is most ubiquitously lacking is a sufficiently broad and comprehensive theory of signs to show the interrelatedness of the various sign systems that are invariably implicated within the scope of the "wide-spectrum" (Martineau et al., 1992) of neurological, metabolic, and behavioral manifestations observed in autism and related disorders. Enter Peircean sign theory. Unlike many contemporary theories of linguistics, cognitive psychology, neurolinguistics, and the like, the thinking of Charles S. Peirce, perhaps the greatest logician, scientist, and thinker of modern times (cf. Nagel, 1959), was notably more profound and comprehensive. Also, more than any potential competitor, Peirce's semiotic approach was grounded in a mathematicized logic which probed the character and limits of

all actual and all possible signs. There is little debate today that Peirce's approach compared to others, even the most contemporary of sign theories in linguistics and related areas, surpasses them all in depth, breadth, and detail of treatment. The level of detail of the Peircean logico-mathematical theory of grammar, as contrasted with those typically applied in school settings, can be compared to that of a photograph as contrasted with a mere line-sketch or even a stick-figure drawing. Recently, Peircean theory has been applied to a wide diversity of theoretical and empirical problems producing significant advances on a wide front (cf. Oller, 1993, 1995, in press a-c).

For example, working within a Peircean framework, it has been possible to develop a series of strict deductive proofs showing that certain kinds of signs (especially those of the true narrative kind—i.e., those which are both narrative in form and that also happen to be true) form the necessary and sufficient basis for normal language acquisition, comprehension, and communication (Oller, 1993, 1994). The theoretical advances enabled by these proofs have already been explored in several areas of empirical research on the interpretability of discursive signs as diverse as still photographs (Giardetti & Oller, 1995), cartoon-strips supported conversational vignettes and videotaped documentaries (cf. Taira, 1992; Taira & Oller, 1994; Al-Fallay, 1994; Tudor & Tuffs, 1991), as well as fully developed abstract narratives (Oller & Jonz, 1994).

In examining empirical research outcomes made possible by semiotic theory, perhaps the most promising aspect is that some of the hypotheses suggested by the theory are quite surprising and could not have been predicted at all in a less comprehensive perspective (for several examples, see Oller, 1995 and in press a-c). For all of the foregoing reasons, we approached the subject of autism with a certain hopefulness that at least some of its secrets might be revealed. From the start, we supposed that the Peircean conception of **indices** (as developed in his fully generalized logic of relations; cf. Peirce 1897) was the crucial theoretical tool needed to explain the unusual associations (or lack thereof) in autism. According to

Peircean logic, an **index** is the only kind of sign that can single out any distinct logical **object** (which may in fact be a plurality of objects, concrete or abstract) for attention. This is strictly provable. By **object**, we mean to include any material object, state of affairs, relation, event, or complex of any and all of these, or in general anything whatever that might conceivably be singled out for attention by any observer (or group of them).

Also, we will argue that the Peircean notion of the **adinity** of any **representational structure** or **text** provides the key to explaining the special limits of autism noted above by Churchill (1978) and DeLong (1991, p. 64-65). In Peircean logic, the **adinity** of any given representational structure can be described as the number of distinct logical objects that must be kept track of in order for them to be related in the intended way within the sign structure in question. What is most noteworthy about Peirce's system is that it generalizes the apparatus for describing such structures to their mathematical limits. Further, it provides the basis for proving that all intelligible syntactic structures (i.e., all of the forms that appear in any kind of text or discourse) involve indices linking distinct kinds of logical objects. Because any kind of mental association logically requires one or more indices to link the associated elements, as soon as we began to study the symptomology of autism in the light of Peircean theory, it was evident that the principal difficulties crucially involved indices. This was clear in all three of the syndromes under examination (Kanner-type or infantile autism, Asperger-type autism, and Williams syndrome). However, to flesh out our theory in sufficient detail, it is necessary to place indexical signs within the broader context of the comprehensive framework. To accomplish this it is essential to introduce the theory of true narrative cases (TNC-theory), that is, the special systems of representations which, as has already been proved (cf. Oller,, 1993, et seq.), form the only possible basis for all other systems ranging from plausible fictions, to errors and lies, and including true, false and indeterminate generalizations, and extending toward the limit of totally random nonsense.

The sign systems on which all the rest provably depend (in the strict deductive sense of

Peirce's mathematicized logic) are true narrative cases (abbreviated, TNCs). The structure of any such TNC involves just the three elements shown in Figure 2. Oddly, such cases involve remarkable complexities

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Insert Figure 2 about here

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and yet are the only source of the meanings upon which any other sign of any degree of intelligibility and complexity can be based. The TNC is one where certain facts (perceptually known) are represented in certain signs (especially discursive or linguistic ones) which are produced by sign-acts (these, being indexical) of an intelligent and suitably-positioned observer (shown at the center of the diagram in Figure 2) so that the signs are made to correspond as perfectly as they purport to correspond to the facts at hand through the articulated sign-acts of that intelligent sign-user (or some plurality of intelligent sign-users).

For instance, suppose there is a VCR in certain classroom and that it was placed there by certain providers of audio-visual services. Suppose further that a certain teacher in that classroom says, "The VCR was wheeled into the room." This statement or countless other possible statements like it would qualify as a TNC because it has all three of the requisite elements shown in Figure 2. The three main elements, the facts, sign-acts, and signs, have furthermore been arranged in a true relationship of correspondence by an intelligent sign-user (who is shown in the background at the center of the Figure 2). Since the statement does not claim very much, it is not surprising that, together with the facts at hand, it actually represents just what it purports to represent, no more and no less.

As a result, for practical purposes, such a representation is relatively perfect (as are all TNCs). Its perfection appears in three critical ways: first, every TNC is perfectly determinate with respect to what it means (i.e., it is determined *relative* to the facts at hand); second, it is, relative to the facts which it purports to be about, perfectly connected, there and then, to the

space-time continuum of common experience; and third, any TNC is perfectly generalizable with respect to its truly determined meanings. That is, whatever determined meanings may be truly associated with the signs in question are perfectly generalizable to other facts like those at hand in all the intended respects. For instance, the term VCR can be applied to any machine similar in all respects to the one at hand, the term "classroom" is applicable to any one like the one at hand, the act of a certain person "wheeling" the VCR into that particular classroom is applicable to anyone wheeling anything anywhere, etc. Furthermore, these perfections are limited only to TNCs and to no others. All other representations, as has been proved, must effectively hitch a ride on the coat-tails of meanings and forms brought to light through TNCs. In addition to its special pragmatic perfections, the TNC, has been shown to be the only adequate basis for language acquisition, or for testing theories of grammar (cf. Oller in press a-b). For all of these reasons, the theory of TNCs provides a uniquely well-suited basis for investigating the riddles of autism and its connections to the wide-spectrum of related neurological disorders.

As it turns out upon further investigation, the elements of the TNC can each be analyzed into a further triad of triads as shown in Figure 3. The facts, as shown in Figure 3, can be resolved into three distinct elements that are perceivable through our senses. First, there are the material objects in their particular factual relations

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Insert Figure 3 about here

(e.g., the VCR and its users in our example); second, there are the animate bodily acts of persons (e.g., such as looking in the direction of the VCR, or turning it on, or moving it from one location to another); and third, there are the surface forms of the signs that mark objects, actions, and signs themselves (e.g., the visible VCR, the sensible act of moving it or turning it on, the audible sound of the statement that "Someone wheeled that VCR in here"). We call each

of these last elements "percepts", and usually (in TNCs), they are correctly taken to be the facts they represent. In Figure 3, the perceptual elements which are in fact always involved in all three positions of each triad, are especially those numbered 1 in each of the various triads. These are always known to us through **iconic** signs—the most obvious, but not the only kind, being visual images. In Peircean theory, these signs are distinct from others inasmuch as icons must really resemble whatever it is that they are signs of. They include such things as perceptual images, photographs, and diagrams, as well as auditory, tactile, gustatory, and olfactory percepts. With respect to perception, as Figure 3 shows in the lower left corner, we find, in normal cases of perception (as contrasted with imagination, fantasy, illusion, hallucination, error, or deception) all three elements of the TNC.

That is, there must be some logical object (broadly construed so as to include singular or plural things, acts of agents, and forms of signs) of perception. There must also be some act (or sequence of acts) by which the observer (the perceiver) notices the logical object. Then, an iconic sign (which is always complex whether it be a sign of a single logical object or some syntactic complex of related objects) is produced in the observer which really resembles its logical object to such a degree that it is taken to be that object. Thus, we find all the elements of Figure 2 (fact, sign-act, and sign) in just the perceptual part of Figure 3. However, it has been rigorously proved (Oller, in press a) that any valid material content of the percept must be altogether a product of the object although it necessarily involves a perceiver in its production.

But, the sign-acts, and the signs, themselves, likewise, can each be resolved into a similar, though in each case a higher, triad of elements. Also, it comes out that the higher triads, especially in TNCs, are mathematically hereditary—that is, they invariably involve the elements of the preceding level. In other words, the elements at position 2 always involve those at position 1 and those at 3 involve both the elements of 1 and of 2. For instance, consider sign-acts. What is different about sign-acts as contrasted with raw facts is that sign-acts are invariably produced by some sign-user acting as an animate agent relative to the facts known

through perception. Even at the first stage, perception involves the perceiver as a secondary part of the production of any percept, but when it comes to intentional perceiving, e.g., looking for the VCR and affirming that it is there, the animate agent takes a more active role and becomes the primary causative agent of the perceptual-act. Thus, some perceptual-act must form the first part of every sign-act of the narrative kind which has any hope of being true. That is, the sign-user must attend to the facts of perception in such a way as to take notice of them perceptually, to recall them, or to imagine them. The second part of any sign-act of the true narrative kind is to articulately link the first part of such an act (the account taken of the facts) with the third part (the signs produced and/or interpreted by the sign-user. Thus, the second part of the true narrative sign-act involves actively taking account of the facts in such a manner as to articulately link them in a true and comprehensible manner to certain signs. The third part of any TNC, therefore, is to link the conception expressed in the signs to the facts as known through perception. In fact, in the original triad (Figure 2) the sign-act falls in the middle position between the facts (which are logically in first position) and the signs (which are logically in third position). Thus, the number 2 is associated with the sign-act as shown in the central triad of Figure 3. However, that number is also associated with every linking between positions 1 and 3 in all of the triads of Figure 3.

Further, it can be rigorously proved that each of the elements that falls to that middling position in every one of the triads is logically an index or a complex of indices. In Peircean semiotic theory, an index is invariably the sort of sign that really connects one or more sign-users with one or more objects. But, since every sign-act originates logically in an agent who actually produces it, the index necessarily involves not only the object or objects to which it connects in the external world of facts, but it also must involve the bodily sign-user who is also connected with whatever object(s) the index may single out for attention (Johnson, 1992). That is, the index logically connects at an absolute minimum the sign-user with that self-same bodily actor in the space-time continuum and in TNCs, sign-acts always connect the sign-user also

with one or more other objects within the continuum. Each object that is indexed in any given case, of course, must be represented first in some sort of icon. The number and kinds of these icons, and the manner in which they are really related by indices, will determine the special complexities of the indexical structure in each instance—i.e., it is the number and character of these indexical relations that determines the adinity of the sign. Interestingly, it is in precisely this indexical aspect of representational phenomena where autism reveals itself.

It is from the special complexities of indices that the apparent ceiling on the number of different kinds of objects the autistic person can handle, as referred to above by Churchill and DeLong, can best be accounted for. In fact, there are fairly severe limits on the numbers of objects that can be taken into consideration by normals as well (cf. Miller, 1956). Of course, these limits can be extended indefinitely by hierarchical arrangements where we treat routinized grammatical structures as units within some higher structure (e.g., by subordination and superordination of elements within grammatical hierarchies). Below, we will return to Peirce's concept of the adinity of relations to see more explicitly just how it is relevant to the observed behaviors of autistics, but before returning to that topic, it will be useful to finish examining Figure 3.

We come next to the triad of elements involved in the signs themselves that appear in every TNC. It turns out that these signs consists of a triad of elements mirroring, in certain respects, the central triad of the TNC just as was true in the case of the facts and sign-acts. However, just as the icon corresponds especially to the elements numbered 1 in the diagram, and the index to the elements numbered 2, those that receive the number 3 in the diagram are all essentially **symbolic** in character. In Peircean theory, whereas the icon is a sign of some logical object only if it resembles that object, and an index is a sign of some object only if it is really connected with it, the **symbol** is a sign of some logical object only if it is arbitrarily associated with that object by habit, rule, or convention. That is, in Peircean semiotics, a symbol is arbitrarily associated with its object by virtue of some particular grammatical system. For instance, there

is no particular reason why we logically ought to call a classroom, a "classroom", but we do use that sign in that way, and for that reason it serves as a symbol of such objects as classrooms by convention.

Now the grammatical convention of associating a certain symbol (or sequence of them) with certain facts (or rather with classes and systems of facts and with their associated meanings) in all TNCs resolves into three distinct elements corresponding to those of the central triad. First, the sign must be given a surface-form that is perceivable. In terms of linguistic theory the perceivable surface-form of a linguistic symbol consists of **phonetic**, **morphophonological**, and **lexical** elements. If the language is a manual-visual one (say, American Sign Language, or some other system used by deaf cultures), the same essential three elements will be found though their perceptual manifestations will be different—in particular instead of phonetic forms distinct visible movements of the body will be used. Second, the sign element in every TNC must involve an articulated internal structure (or **syntax**) which relates whatever parts the sign structure may have in such a manner as to form the basis for an articulate conception or meaning (the **semantics** of the sign). Looking back then to the central triad, the articulation of the signs relative to the facts of the TNC through sign-acts constitutes the fundamental pragmatic aspect of the whole structure (the **pragmatics** of the sign in its systematic applications by intelligent users). Further, as has been shown (cf. Oller & Kennedy, in press) the semantic and syntactic aspects of signs are utterly dependent in the final analysis on the pragmatic facts as known through valid perceptions. Remove that pragmatic element altogether and no facts whatever can be determinately known, nor can any signs acquire any significance with respect to their structure (syntax) or meaning (semantics).

With all of the foregoing in mind, we return, then, to the matter of the **adinity** of any relation. Now a relation that holds relative to one or more logical objects, it turns out, is exactly like a predicate which is true of one or more arguments. That is, the act of pointing to the VCR is similar to the act of saying, "Look! That is a VCR!" They are similar because they involve

similar logical structures, though the linguistic sign does involve more than the pointing does. In fact, the syntax of the act of pointing is contained within the syntax of the linguistic utterance. Thus it is that any genuine relation whatever is essentially a syntactic relation that obtains between one or more signs for objects (broadly construed) and one or more signs for some general predication(s) about the object or objects singled out in the relation. In the case of TNCs, the logical objects singled out for attention require indexical marking to single them out. The relation itself, on the other hand, requires the objects between which that relation holds in order for the relation to be materialized at all—i.e., in order for it to exist, much less to be signified. For instance, say someone is pointing to a car going down the road but all of a sudden both the car and the someone are utterly removed from existence past, present, or future. What happens to the relation by which the someone was pointing to the car? It too ceases to exist. Thus the relation inheres in the very objects between which it holds. Otherwise, it has no real existence but is a pure abstraction.

Just so, by a little further logical work we discover that the special characteristics of any relation whatever are completely contained within the syntactic structures that involve the objects that have the relation in question. But, these syntactical elements are entirely a function of the particular arrangements of particular objects in real space and time, or in some imaginary world that is known to people in real space and time. Thus, all the particular characteristics of any relation whatever are contained in the particular arrangement of the particular objects between which the relation holds, and as a result, all that is left for the general or universal aspect of relations is whatever may be general to all possible logical objects. Upon further inspection, as Peirce discovered, the only generality of any relation is simply the number of objects between which that relation may hold—that is, the adinity of the relation. Therefore, all possible syntactic relations may be described as involving one, two, three, or more logical objects designated by indices. A structure involving only one object he termed a **monad** (following Leibnitz); one containing two indexed objects he called a **dyad**; those containing

three he termed a **triad**; and those involving greater numbers he called **polyads**. The number of elements required to complete any given relation Peirce called the **adinity** of that relation. The adinity of any relation, then, is simply the number of logical objects that must be indexed in order for that relation to be manifested in its complete form. Or, taking a particular structure such as "The hotel worker brought the VCR into the room", if the indexed objects were erased from the structure, we would have "_____ brought _____ into _____" . Thus we find the structure in question to be triadic, or, putting the same fact in different words, the structure has an adinity of three.

Interestingly, Peirce was able to show mathematically that any monad or dyad, could be expressed as a triad, and that any polyad whatever could be expressed as a complex of triads, but that no complex of monads could express even a dyad much less any higher adinity and neither can a dyad express a triad or any higher adinity. As surprising as it may seem, these findings have profound implications for grammatical theory and, perhaps, may provide the key to the mystery of autism. Apparently every sign-structure is something like a chemical atom with certain loose ends or unsaturated bonds (Peirce's analogy) seeking a suitable resting place or a situated object to which to attach themselves. Or, it is like an enzyme with a peculiar stereoscopic structure which can be fitted to just certain kinds of molecules. In the case of the extreme Kanner-type autism, it would appear that the subject can only deal in monads. That is, each time the perceptual screen lights up, or changes to a new scene or part of a scene, it is as if the world were suddenly made anew. There can be a gradual slurring of one scene into another, but all that is ever before the conscious attention of the extreme Kanner-type autistic, it would seem, is one monadic percept of a brief segment in time. However, owing to the nature of the monad, as the attention or bodily location of the autistic subject is changed, the monad previously present is simply replaced by another, and the more rapid the transition the more naturally it will tend to produce a sense of panic that the world is changing in some out of control manner. Without a capacity to link the distinct monads into a series of linked dyads,

or the universal triad of past, present, and future, the peculiar anxiety associated with autism in its most severe forms is quite predictable.

Further, if a severely autistic individual is cognitively limited to relations with an adinity of one, it will be logically impossible for that individual to develop a concept of self (ego) as distinct from other (alter), or even self as distinct from the perceptual monad (id) of which the iconic representation of the austistic's own body is part. In extreme autism of this kind, it will be impossible also for the autistic person to develop a system of representative signs or to engage in meaningful social interactions. The naturally expected result of attempts to get a severely autistic person to participate in social interactions (e.g., in therapeutic settings) can be expected to produce the very panic attacks commonly observed in extreme autism (see Kenardy, Fried, Kraemer, & Taylor, 1992). Further, the seemingly bizarre behavior of persons afflicted with extreme autism described by Sacks (1994, p. 106) as "finger play or flapping of the hands" also can be explained. Whereas the world appears to be a series of unconnected and very distinct "snapshots" (to borrow the term of Martineau, et al., 1992) in an unknowable and terrifyingly complex series of unending surprises, the seemingly bizarre movements of the autistic person's hands, fingers, or even some commonly available object (for one 9 year-old girl we observed, a strip of paper torn and folded just so) rapidly moved back and forth before the eyes may, with repetition, acquire a certain perceptual familiarity. Also, even though the most severely autistic persons probably cannot consciously produce these stimuli, because their hands are always nearby, these strange repetitive motions come dimly under the control of their wills and provide a kind of familiar landmark, a reference point, to a person who is effectively lost in a sea of unconnected and, judging by the nature of observed responses of severe autistics, almost invariably unpleasant surprises.

Such appears to be the plight of the most severe autistics, i.e., those whose adinity is limited essentially to monads of perception. But, suppose the individual were able to achieve dyadic relations and by virtue of familiar end points for some of these to conjoin the dyads to form

a connected road through the welter of perceptual images. An autistic at a dyadic degree of severity could be expected to form some associations between gestures and objects, between pairs of objects, and thus could develop a limited sense of personal identity as a bodily presence within the broader spatio-temporal continuum. Verbal or gestural signs, or at least their surface forms, could also be crudely attached to distinct percepts. Among several autistics observed recently by the authors, for example, hand gestures were used to display a desired object (e.g., the opening of the hands to get someone to bring a phone book by an eleven year-old boy, the clapping of the palms in a certain orientation to get a sheet of paper by a different nine year-old boy, a hugging gesture and clinging to maintain pleasant physical contact, and so on). In these cases, however, owing to the fact that dyads linked end-to-end are still dyads, the theory predicts the commonly observed terror, anger, and general panic displayed by such dyadic autistics when the therapist, parent, or care-taker tries to deviate from the familiar linear routine or temporal sequence. It also shows how the dyadic autistic will be able to handle familiar names, words for visible or other sensible actions that can be performed on one or two objects, and why that individual will be confused or overwhelmed by a task that involves three or more logical objects that must simultaneously be connected within the scope of a single predication.

Just as was noted by Churchill (1978) and by DeLong (1992), a person limited to an adinity of two will not be able to manage all of the requirements of any sign that requires tracking of a relation between three distinctly indexed objects—e.g., a conversation involving triadic relations will seem incomprehensible. For instance, "Sally gave Maria the crayon; It's Maria's crayon; You must give it back to her"; and so forth, will not be fully comprehensible to the dyadic autistic.[1]

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[1]Further it is possible to prove logically that conceptions of continuities (whether of individuals across time, classes of a mathematical sort, or the kind of continuum we see in the space-time manifold) and therefore the Piagetian-type conservation tasks will necessarily remain out of reach (cf. Oller, in progress).

But what of an individual who can manage up to an adinity of three? Owing to the special properties of the triad and the fact that all higher adinities can be achieved through conjoined triads, an individual at this level will be able to manage many complexities out of reach to monadic or dyadic autistics. Persons operating at an adinity of three would be able to acquire many ordinary structures of natural language systems. They might very well excel in subsequently developing associative skills not requiring higher adinities. Hence, autistics at this level might well display the special gifts commonly attributed to autistic savants (e.g., keenly developed computational and/or musical abilities). However, in a social situation where more than three objects need to be put in relation to each other in order to manage the situation, e.g., when following a conversation between more than two persons, the high-functioning autistic at an adinity of three, will, it is predicted, find a ceiling beyond which it will be difficult, and in some respects, impossible to manage.

Between an adinity of four and about nine, presumably, all the rest of the world can normally be found. According to the long-standing research of Miller (1956), very few individuals can manage declarative relations involving numbers of objects beyond seven to nine unless the objects are re-arranged in the manner of a grammatical hierarchy so as to involve more than one layer of abstraction simultaneously. But even if the latter route is followed, evidently there are still limits owing to the difficulty of managing more than three or four degrees of abstraction while simultaneously keeping track of one, two, or three, distinct objects at each level. While there is no doubt that automatization of the sort made possible by the internalization of grammar can enable language users to continue almost indefinitely to expand the envelope of the adinity of relations that they can express and understand, it would seem that the natural limits on adinity can never fully be removed. Still, normal persons with the aid of the hierarchical structures of a natural language (i.e., a grammar) and its parasitic attachments of literacy and mathematical notation, can indefinitely expand the envelope so as to accomplish cognitive tasks that are far beyond the reach of even high-functioning autistics

or, as we will see, subjects with Williams syndrome.

So Is Autism an Affective or Cognitive Disorder?

With all of the foregoing in mind, we come back then to the question about the cognitive versus affective nature of autism. The controversy seems already resolved in favor of the cognitive alternative. Clearly it is a kind of disorder involving the whole range of capacities to form indexical associations between the objects of experience. However, when we examine closely the constellation of symptoms supposed to show autism to be an affective disorder we discover that every indicator of that kind involves one or more indices as its principal component. For instance, Huebner (1992) mentions "difficulty recognizing emotional gesture" (p. 488), "social aloofness" (Fein et al., 1986), inability to understand "complex emotional expressions" (p. 489), "facial expressions", "body language and empathy", "pretending skills" (Grandin & Scariano, 1986), and "difficulty in imitating arm and hand gestures, thus suggesting dyspraxia" (Huebner, 1992, p. 493). Yet each of these indicators of emotional states whether directed to the autistic person or coming from that person and noticed by someone else remains essentially indexical. As such, every affective manifestation always requires a minimal dyadic adinity in order for it to be taken into consideration as a sign of anything whatever. However, to take an affective manifestation as a sign of an attitude or feeling in someone else, even a triadic adinity will not suffice.

When it comes to concepts such as "empathy", "compassion", or "cooperativeness" an adinity of four or more is needed. That is, in order to express understanding of someone else's feelings as expressed in body movements, facial gestures, postures and the like, it is essential to link the affective signs with the states of mind of the other person as distinct from the self. Further, the states of the other person must be understood in terms of similar states that one has experienced in one's own world. Hence, there is (1) the manifestation of affect (the facial expression, tone of voice, choice of words, or what-have-you). Next there is the relation of that

behavioral sign to its (2) logical object. However, if the affective sign is to be understood in relation to its logical object, the relation of the sign to (3) the person producing it must be understood. Yet, (4) the person doing the understanding of all the foregoing must also be related cognitively to all of the foregoing elements. That is, the understanding person (the one who expresses empathy, compassion, or mere comprehension of the other party's feelings must consider all of the foregoing from that other person's point of view. Therefore, no less than an adinity of four is needed. If the plot is thickened by adding one or more additional persons besides the self and a single other party, considerably higher adinities will be demanded.

As a result, the theory predicts the common observation that even very high performing autistics (e.g., Temple Grandin), that they have difficulty understanding the emotions of other people. Grandin, according to Sacks (1994, p. 124) told him, "When I look up at the stars at night, I know I should get a 'numinous' feeling, but I don't. I would like to get it. I can understand it intellectually. I think about the Big Bang, and the origin of the universe, and why we are here: Is it finite, or does it go on forever?"

"But do you get a *feeling* of its grandeur?" he asked.

"I *intellectually understand* its grandeur," she said. "Who are we? Is death the end? There must be re-ordering forces in the universe. Is it just a black hole?"

Thus it comes out both from empirical observations and from the theory itself that the capacity to experience emotion fully, e.g., as a means of connecting the grandeur of a present experience with all that has gone before and may come after, remains beyond the reach of any person with an adinity restricted even to the triadic level. At any rate, the possibility of such an explanation is worthy of consideration and based on the semiotic theory under consideration we find three major classes of indices. These are not the only classes that exist, but they are the central kinds of greatest service in the analysis underway. First, there are the kind that link a perceiver with any logical object (keeping the term broad as always) through a perceptual act of that perceiver. Second, there are the kind of indices that an intelligent agent can produce by

intentional and voluntary movements of the body. There are also, of course, involuntary and unintentional movements that also produce classes of indices, but those would fall into the class of mere monads from the view of the theory. Third, there are the several kinds of indices involved in volitionally and intentionally produced signs. In this last class, three important subclasses can be distinguished: there are indices that link signs to objects—that is, to facts and sign-users who are involved in those facts; indices that link sign-forms to other sign-forms; and indices that link sign-forms to conceptions. Oddly, it should be noted, conceptions cannot be linked to anything at all apart from signs and/or objects, so there is no class of indices linking conceptions directly to conceptions without any intervening signs or objects.[2]

Thus, every genuine index invariably involves a bodily agent. If it is an index of any of the several kinds just described in the preceding remarks, it must also involve at first the volition of the agent. That is, the agent wills to look in a certain direction, and intends to do so before moving the body (or even the eyes) in such a way as to bring about that result. Or, the agent wills to express a certain idea or conception, intends to do so, and then, assuming that the neurological apparatus is intact, is able to cause the muscles of the body to move in such a way as to bring about the intended act or sequence of acts. When the act involves merely producing a sequence of signs, e.g., as in saying "They did deliver the VCR", there is still a dim possibility that the agent will run amok and misspeak. This possibility exists because of the universal degeneracy of indices. As Peirce showed more than a century ago, any index is like a line pointing vaguely in a certain direction. It may touch many objects that are not its intended target, and it may even miss its target entirely. We look there at the left, but the VCR may have been moved somewhere else. We intend to type "of the" but instead, what comes out on the screen is "other". Exactly how and why this happens, we do not know, or at least not exactly, because indices by their very nature include a special kind of inexactness or degeneracy.

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[2]Even mathematical reasoning relies on signs of conceptions in order for those conceptions to be linked to anything at all. Besides, the theory of true narrative cases rigorously shows that this must be the case, and Peirce had proved the case through his logic of relatives long before.

However, when it comes to the meanings associated arbitrarily with certain signs (especially linguistic ones), much of this inexactness, if not all of it, is removed. That is, to function as a sign conventionally associated with a particular meaning (or concept), the sign must produce the concept conventionally or else it is no sign at all. Thus, the association of a sign-form with whatever meaning may be conventionally assigned to it involves an absoluteness that is not found in indices. However, even with the abstract meaning of a sign-form an abstract index must be involved because more than one meaning may be associated with any given sign-form, so there is still room for error. And with abstract signs, as Einstein (1941) sagaciously noted, there is ample opportunity for deliberate deception.

So we come finally to the neuroanatomical basis of willful (volitional) and deliberate (intentional) physical acts (indices) as the possible key to unraveling the mystery of autism. For the moment we set aside the purely mental kinds of acts involved in the third element of the central triad of Figure 3 along with the perceptual element. We analyze the central category of physically executed sign-acts (e.g., deliberate attention as in moving ones eyes or turning toward the source of a sound; uttering a sequence of words; or merely attending to words or gestures of someone else) into three main components as shown in Figure 4.

Insert Figure 4 about here

First, there must be some kind of representation (perceptual, linguistic, or conceptual) of two or more alternative courses of action. For instance, we could look there where the VCR is, or elsewhere; we could say, "There is the VCR", or we could say something else; we could attend to the uses of the VCR that someone is speaking of, or something else. In this mental representational phase of physical sign-acts, we can predict that the neurological activity which enables any such act to take place must itself happen relatively quickly and without noticeable bodily movements. That is, since it precedes the bodily movements involved in the act, the

mental phase of intention must, therefore, consist of neuronal activity of an essentially electrical variety.

Second, in addition to the representation of alternative courses of action (however dimly these may be consciously realized), intentional acts generally involve an arbitrary choice of one course over another. However, once the arbitrary choice is made, to execute any intentional act requires the intention itself to be on hand already. This then must be the outcome of the prior step and the arbitrary choice of just that intention rather than whatever others might have been selected. This elected intention, then, must be represented in some way within the agent-actor. Presumably it is represented in an electro-chemical firing of neurons in contact with muscle tissues. The second step begins, presumably, when the intention is clear enough to begin to produce a motivation to act.

At this stage, the activity is such to initiate and to sustain the third phase of the act: one or many muscular contractions. As the muscles begin to contract, we come to the brink of that third phase—the production of the physical act. Here, metabolism of energy occurs and mechanical forces are exerted so as to produce the act itself. This act is invariably indexed against the actor and against whatever objects that actor may act upon. Summing up, physical acts involve (1) electro-chemical events, (2) followed by metabolism in muscle tissues, (3) followed by mechanical forces exerted upon bodily objects. In sustained acts, such as running a marathon, there will be a continual cycling of these elements in an overlapping and repetitive fashion. Interestingly, these three elements may be related to three fairly distinct systems distinguished even at the level of neuroanatomy.

Using positron emission tomography Horwitz et al. (1988) were able to map the neuroanatomy of 14 autistics whom they compared to 14 normal subjects. Huebner summarizes:

> They found a disruption between the frontal and parietal lobes' interaction with the thalamus, caudate nucleus, and lenticular nucleus...compatible with neurological impairment in the complex attention network. That network has three basic components: (a) the reticular structures, which are responsible for

> arousal, (b) the limbic lobe [where the crucially important hippocampus is also located], which provides the motivational element, (c) and the frontal parietal lobes which are responsible for integrating sensory and motor components of directed attention (1992, p. 497).

Huebner goes on to cite Westman (1990) as showing that

> the four functions of the frontal lobes are: (a) to maintain focussed attention and regulate awareness, (b) to recognize strategies and execute behavior, (c) to sequence and plan skilled acts or thoughts, and (d) to make choices and initiate action (p. 497).

With all the foregoing in mind, we can hypothesize that extensive damage to the limbic system insofar as it connects with the reticular formation and neocortical systems will be found in the most severe cases of autism (see Figure 5). In fact, even though the perceptual apparatus might remain

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Insert Figure 5 about here

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intact, in cases of such damage, sign management would be reduced effectively to an adinity of one. In these cases, owing to the proximity of the reticular formation to the cerebellum and the neocortical systems involved in balance and general muscular control, it can also be hypothesized that severe autistics will be apt to suffer from symptoms similar to those observed in diseases such as cerebral palsy and parkinsonism—an empirical fact already established. However, in the case of more limited damage to the limbic system (and especially to the hippocampus, per the research of DeLong and that of Martineau and colleagues) less severe autism would be expected. Assuming that some of the hippocampal tissues remain intact, we would predict adinities of 2 and higher for the persons affected. Presumably, adinities of more than 2 would require more than one viable pathway to maintain the indexical links between objects and their corresponding abstract concepts. While the object (including any perceptual scene or complex) in its monadic existence can be known essentially through the perceptual apparatus, if the percepts are to be linked to each other in meaningful ways, it would seem that

higher cortical functions in the frontal and parietal lobes would have to become involved. Hence the critical role of the intermediate limbic system. The research shows that the hippocampus is specially involved in the storage and retrieval of memories that are built up in the perceptual way.

If it is destroyed, as shown most dramatically in the well-known case of Clive Waring[3], many of the sign-management functions remain intact, but the ability to form new memories of objects linked in the manner of past and present becomes impossible. Still, Waring's capacity to talk about what is going on in his own phenomenal present tense seems relatively unaffected. Evidently, the hippocampus is crucial, as DeLong and others have noted, to the building up of indexical structures. However, once the indexical hierarchies have been constructed, the hippocampus is no longer crucially involved in applying them. That is, the routines of past experience can apparently be invoked by perceptual experience, just as Clive Waring can direct music, play a familiar piece of music flawlessly on the piano, and the like. The hippocampus is critically involved in the declarative, present-tense, conscious linking of past and present experiences. Therefore, if the hippocampus is destroyed (or never develops) prior to the building up of temporal links, such links cannot be established in the first place. Had Clive Waring sustained the same damage to his limbic brain system at an earlier age, he would presumably have been a rather severe autistic. But, if the needed hierarchies of sign systems have already been established, the structures themselves remain more or less intact and what is lost is the ability to relate them to others that have occurred in the past, or that might occur in the future. Hence Mr. Waring cannot recall his past at all nor can he anticipate anything in his future. The surprising familiarity of the sign-structures previously experienced, after the trauma, has become to Mr. Waring an unsolvable mystery.

Among the puzzles he faces is the evident fact that he really does "know" his wife, in a

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[3]A mental patient whose hippocampus was evidently destroyed by a viral infection, as seen on the PBS series, *The Mind*, produced by WNET/New York, Educational Broadcasting Corporation 1988.

sense, though he hasn't any recollection of having ever seen her before. That is, he cannot connect the previous occasions when he has known her before with the present one, except in the sense of a delightful familiarity that he finds in each seemingly brand new present occasion. Thus, our theory suggests that if his brain damage had occurred in infancy, Mr. Waring would have suffered from infantile autism. What he is able to manage after his brain was severely damaged, particularly in his hippocampus and limbic system, are perceptual monads of experience previously analyzed into complex structures that formerly had higher adinities. However, all of the analysis of those structures occurred prior to the severe damage his brain later sustained. His post-traumatic sign-structures, therefore, now appear to him as mysterious unrelated monads, each new occasion as big a surprise as the previous one. Still, the monads that he can handle are remarkable for their complexity—a complexity that was built up over years of experience prior to his brain trauma. Yet now, each new perceptual segment of reality, that is, each brief loop of the videotape (not much more than thirty seconds to a minute or so) of experience, a snapshot without the rest of the album, seems totally unconnected to anything experienced previously. It is as if Mr. Waring had just awakened for the first time in his life.

Williams' Syndrome as Distinct Kind of Disconnectedness

Finally, then, we come to the special case of Williams syndrome. While we do not suppose that Williams syndrome ought to be called a variety of autism, we do contend that the special manifestations observed are owed to the inability to manage certain kinds of cross-modal indices. Further, we note that the neurophysiology and anatomy of Williams syndrome seems essentially to involve coordinations between activities in the frontal-parietal lobes in conjunction with the entire sensory-motor system. For instance, consider the coordinations that are involved in drawing the distinct parts of an elephant into a whole picture of it, or, those of a person riding a bicycle (Figure 1 above). Or, consider the coordination of conversation and discourse with sensory-motor acts in general. It is necessary in these cases to integrate sign-structures of

distinct kinds across modalities. For instance, to draw the elephant, we must distinguish and maintain in proper relationship the head, trunk, body, legs, and tail as we construct the image on a flat sheet of paper. In the latter case, we need to distinguish the parts of the cycle in their special relationships, their orientation relative to the road and rider, and then to project these distinct images, together with their separate but interrelated parts, onto a flat surface.

While the person with Williams syndrome can often handle separate temporally arranged verbal sequences of some complexity, and while they may even seem to make sense of those verbal sequences after a fashion, as soon as it comes to linking such sequences with spatio-temporal facts in the world of experience and with actions that require simultaneous management of complex sign arrangements of the sensory-motor kind, the semiotic system of the person affected by Williams syndrome seems to break down. The problem comes, it seems, exactly in the indexical connections of the hierarchically structured temporal kind of sequences (sign-to-sign indices of the verbal and/or conceptual kind) with spatio-temporal structures of objects and sign-relations (object-to-object and sign-to-object indices). To accomplish these integrations, according to Bellugi and her colleagues (1992),

> Williams syndrome subjects tend to talk their way through drawing tasks as if using their verbal skills to mediate the severely impaired act of drawing... (p. 215)

Yet the impairment is evidently not one of perception because Williams subjects characteristically can recognize faces, facial expressions, and orientations without much difficulty (Benton, et. al, 1983). They may even excel in these tasks which is one of the reasons that they appear to be so different from autistics. It is apparently in the conceptual *integration* of perceived relationships of the spatio-temporal kind *together with* essentially temporal discursive relations where Williams patients have the greatest and most characteristic difficulty. Bellugi and colleagues may have pinpointed the neurochemical basis of this peculiar disorder. They have noted that Williams syndrome is

> associated with high levels of calcium and abnormal calcium metabolism...recently...shown to include a deficiency in the synthesis or release of calcitonin (Culler et al., 1985).

As a result, they are working to test the hypothesis that Williams syndrome may be due to

> a genetic disturbance...which results in the abnormal production of calcitonin and of a neuropeptide that may play a role in the normal development and/or function of the central nervous system (pp. 227-228).

In Conclusion: Linking Infantile Autism, Asperger Syndrome, and Williams Syndrome

We conclude, then, with reference to Figures 4 and 5 (see above). Severe damage to the reticular formation and/or the intermediating limbic system will, it would seem, prevent even the intention to perform an indexical act from shaping up. In that case, we should see a severe Kanner-type or infantile autism—in the most severe cases we will see a semiotic system with an indexical adinity of one. If the limbic system, especially the hippocampus, is damaged, depending on the severity of the damage, we can expect an autism of greater or lesser severity tending toward the really high-functioning Asperger-type. As the severity of damage diminishes, presumably, the adinity of the sign-structures that can be managed will corespondingly increase. If the production of calcitonin and its associated neurotransmitters which are essential to the intensive coordination of frontal-parietal activities with sensory-motor sign-systems should be disrupted, apparently Williams syndrome will result. No doubt many details of these three puzzling syndromes remain to be worked out, but we believe that the linchpin of each one is the special and indispensable role played by particular kinds of indices in sign-management functions.

Acknowledgments

This paper was prepared originally for presentation at the annual meeting of the American Association of Applied Linguistics in Long Beach, California, March 27, 1995. The authors especially thank Susan L. Windeck, Occupational Therapist and President of Albuquerque Therapy Services for providing opportunities to participate in sessions with autistic individuals. This research was supported in part by a grant to the second author from the Maternal and

Child Health Interdisciplinary Leadership Training Program under the auspices of the New Mexico University Affiliated Program, Health Sciences Center originally funded through a $400,000 federal grant from the Department of Health and Human Services to the UNM School of Medicine. All of these parties are especially thanked and at the same time absolved of any special responsibility for what is said here. The ideas expressed, and any errors they may contain, are our own.

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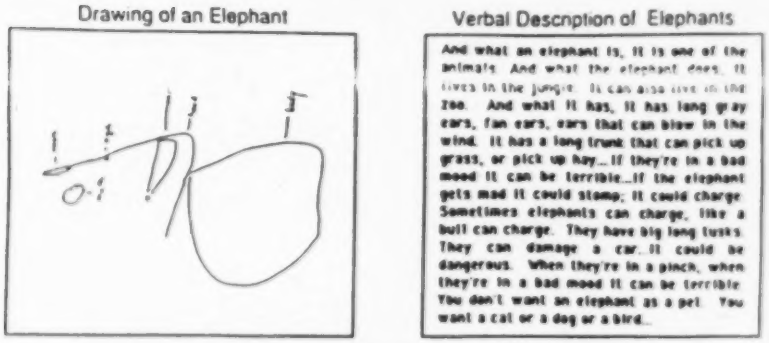
Contrast Between Visuospatial and Language Abilities in Williams Syndrome


Drawing of an Elephant
Verbal Descnption of Elephants
And what an elephant is, it is one of the animals. And what the elephant does, it lives in the jungle. It can also live in the zoo. And what it has, it has long gray ears, fan ears, ears that can blow in the wind. It has a long trunk that can pick up grass, or pick up hay... If they're in a bad mood it can be terrible...If the elephant gets mad it could stomp; it could charge. Sometimes elephants can charge, like a bull can charge. They have big long tusks. They can damage a car. It could be dangerous. When they're in a pinch, when they're in a bad mood it can be terrible. You don't want an elephant as a pet. You want a cat or a dog or a bird...
18 year old Williams Subject

Drawing of a Bicycle Age and IQ Matched WS and DS Subjects

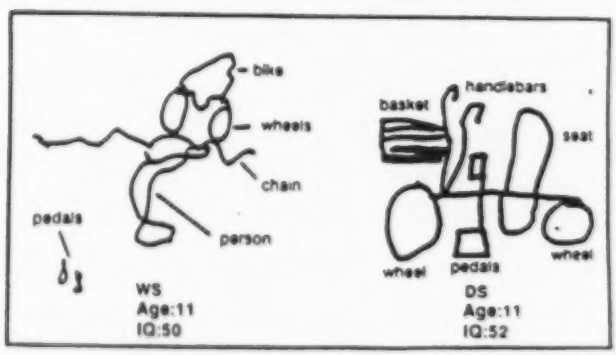


Figure 1. Top: A drawing and description of an elephant from a person with Williams syndrome. Bottom left: a drawing of a person on a bicycle from an eleven year-old individual with Williams syndrome. Bottom right: a similar drawing from a person with Downs syndrome matched for age, IQ, and gender to the Williams case at the left. (From Bellugi et al. 1992, p. 217.)

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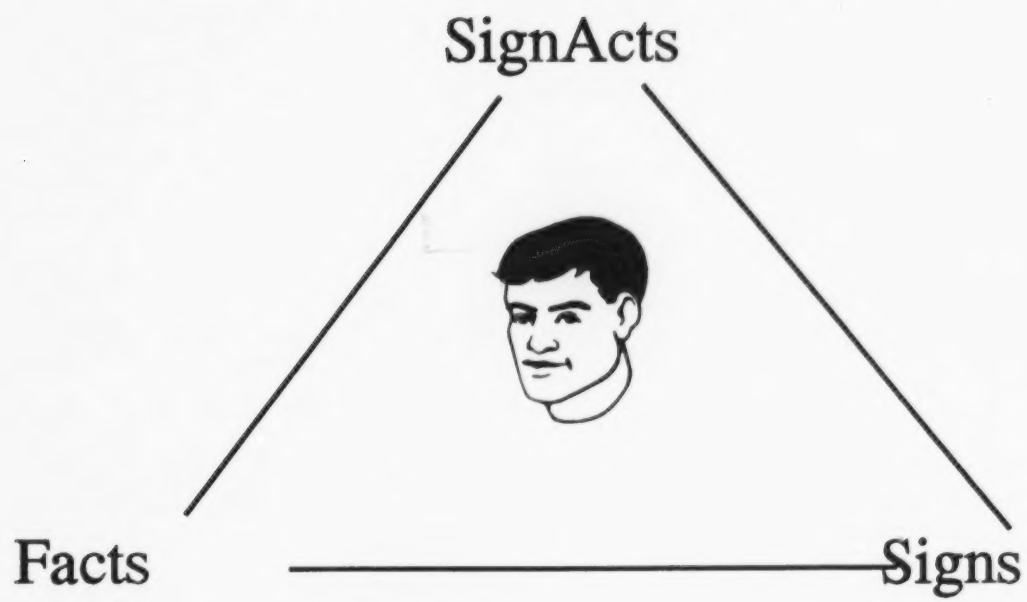

Figure 2. The three main components of ordinary true narrative representations.

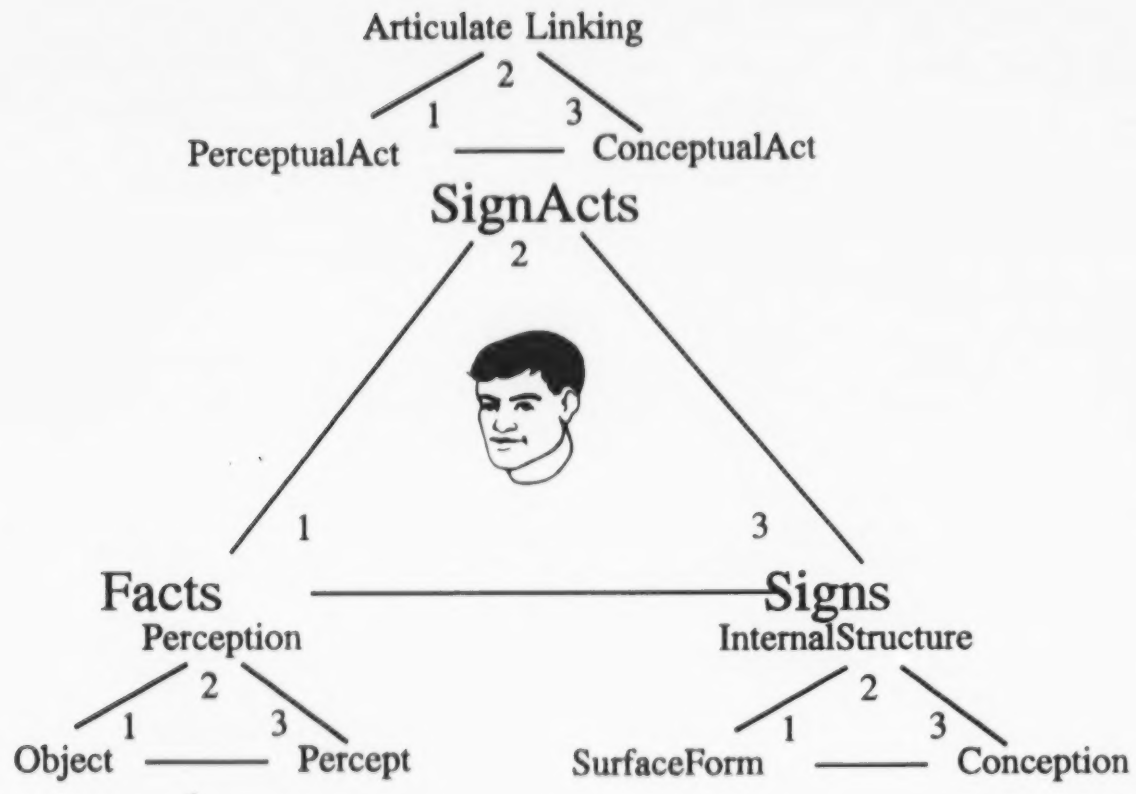

Figure 3. A closer look at the underlying structure of the basic sign triad.

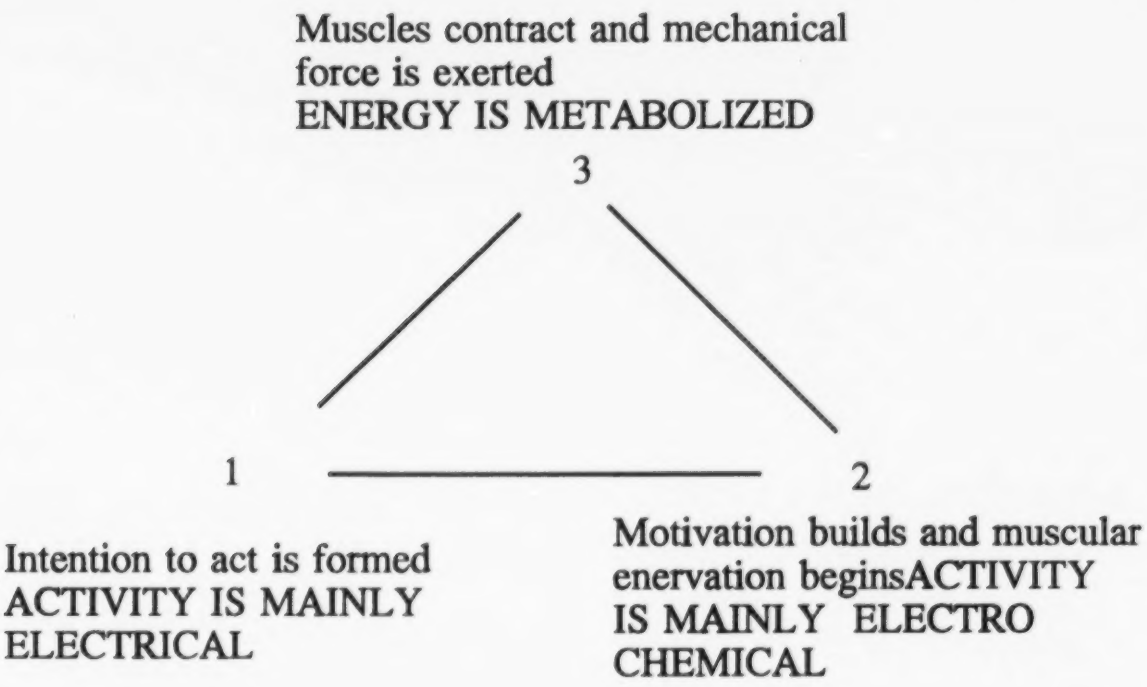

Figure 4. The three main components of an indexical act from a neurological point of view.

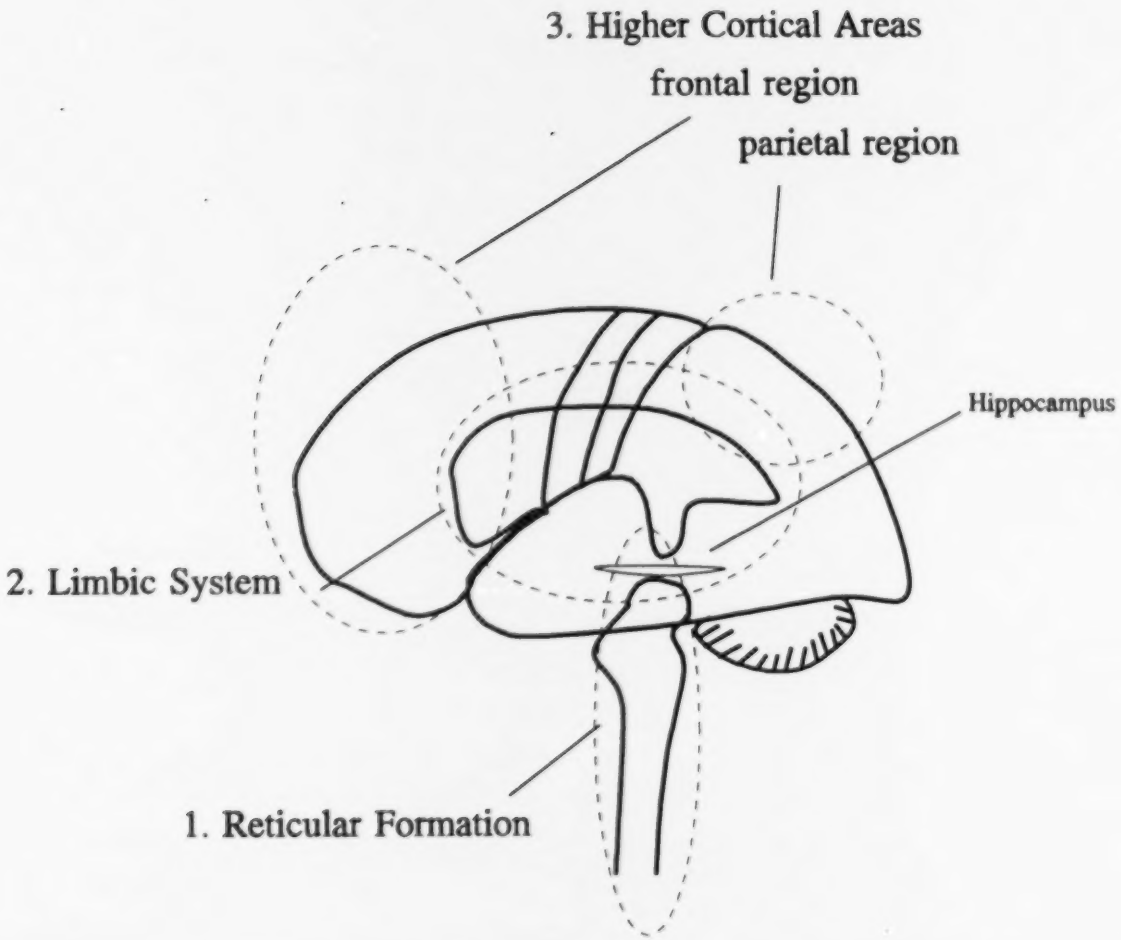

Figure 5. Three neuroanatomical systems linked to (1) Kanner-type autism; (2) Asperger syndrome; and (3) Williams syndrome.